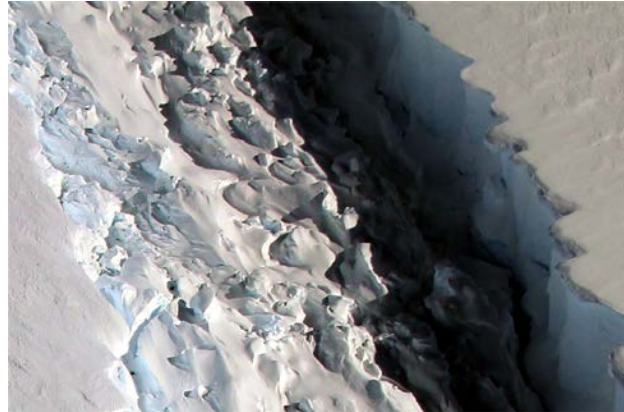
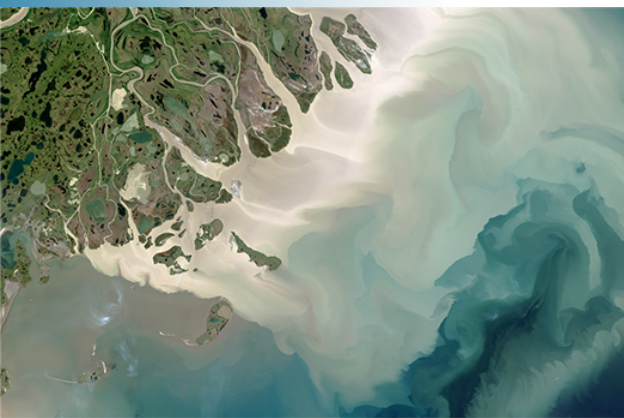


SCIENCE



FY18-19 Overview/Summary MODIS/VIIRS Science Team Meeting

Sandra A. Cauffman
Deputy Director, Earth Science Division

October 2018

Outline

- *Appropriation/Budget Status*
- *Flight Program Status and Plans*
- *Earth Venture Opportunities and Hosted Payloads*
- *Small-Satellite Constellation Data Buy Pilot*
- *Earth Science Partnerships*
- *Non-Flight Program Plans/Highlights*
- *2017 Earth Science and Applications from Space Decadal Survey*

NASA/ESD Appropriation: FY18, FY19

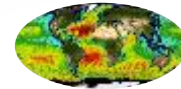
- FY18 (1 Oct 2017 – 30 Sept 2018) funding – appropriated via an Omnibus – is at the **FY16/FY17** level (~\$1.92B)
- Continues operations and development of FY17 Program of Record (including DSCOV R EPIC/NISTAR, PACE, CLARREO-PF, OCO-3 (to launch as manifested by February 2019))
- House Appropriations Committee marked up the FY19 NASA/ESD budget in April, 2018
 - Original text had ESD authorized at \$1.45B in FY19
 - Amendment to increase ESD appropriation to \$1.92B passed by a vote of 27-5 !!
- Senate Appropriations marked up the FY19 budget in May
 - \$1.925B in FY19
 - However, this ***includes*** restoration of OCO-3, DSCOV R ops, PACE, CLARREO-PF
- **The Earth Science Division funding is substantial and is expected to remain at a high level for FY19 and beyond**

NASA Earth Science Division Elements



Flight (incl. Data Systems)

Develops, launches, and operates NASA's fleet of Earth-observing satellites, instruments, and aircraft. Manages data systems to make data and information products freely and openly available.



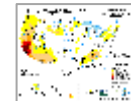
Research & Analysis

Supports integrative research that advances knowledge of the Earth as a system. Six focus areas plus field campaigns, modeling, and scientific computing.



Technology

Develops and demonstrates technologies for future satellite and airborne missions: Instruments, Information Systems, Components, InSpace Validation (cubesat and small-sat form factors).



Applied Sciences

Develops, tests, and supports innovative uses of Earth observations and scientific knowledge to inform private and public sector planning, decisions, and actions. Activities include disaster response support and capacity building.

- (Pre)Formulation
- Implementation
- Primary Ops
- Extended Ops

NASA Earth Science

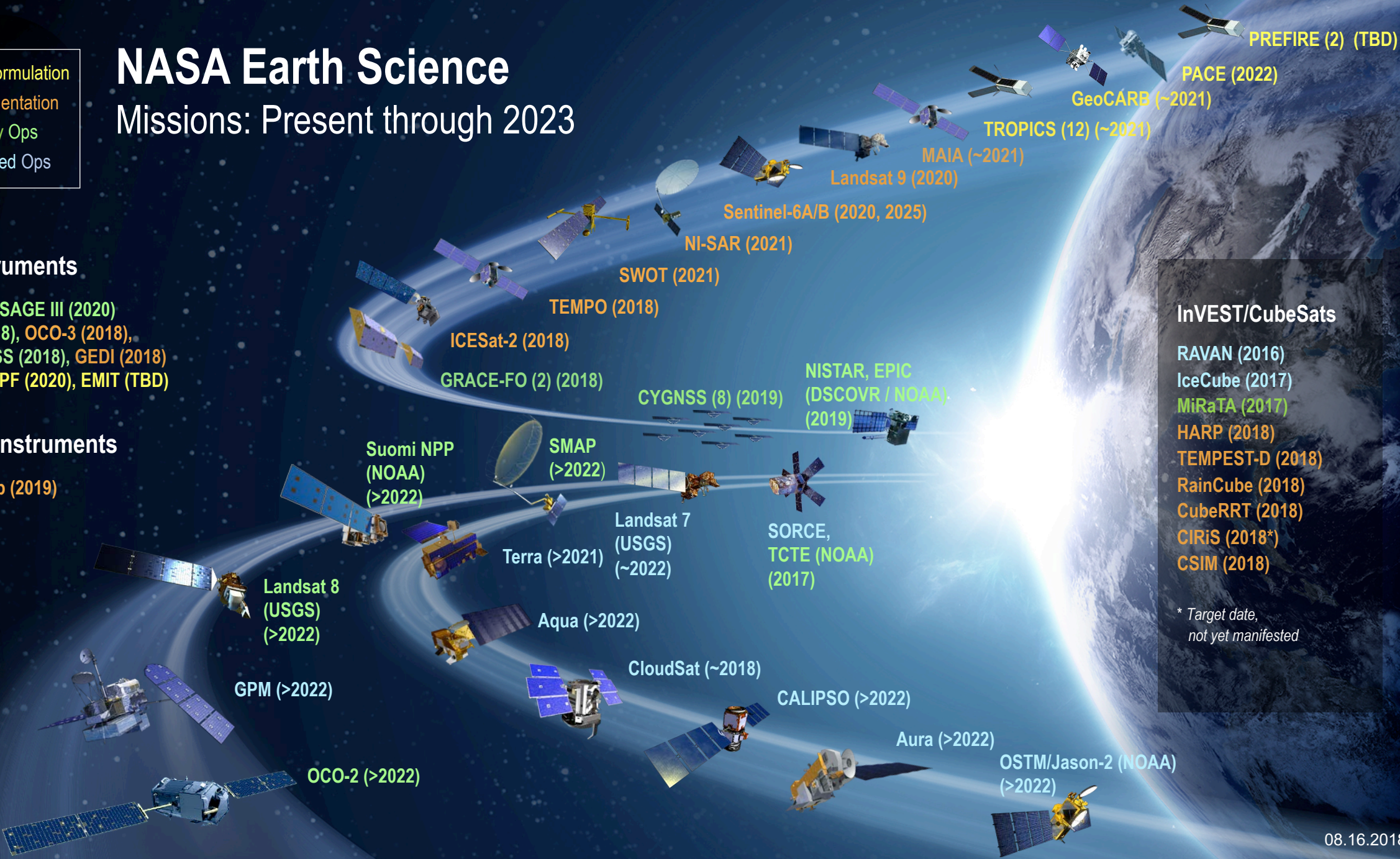
Missions: Present through 2023

ISS Instruments

LIS (2020), SAGE III (2020)
 TSIS-1 (2018), OCO-3 (2018),
 ECOSTRESS (2018), GEDI (2018)
 CLARREO-PF (2020), EMIT (TBD)

JPSS-2 Instruments

OMPS-Limb (2019)



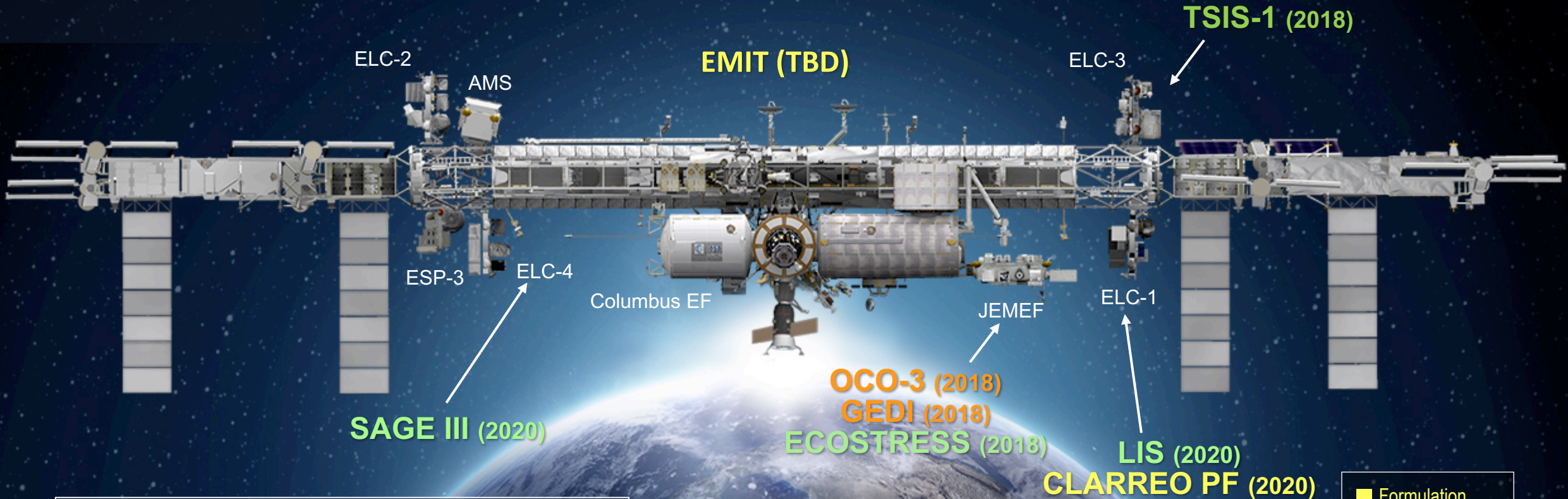
InVEST/CubeSats

RAVAN (2016)
 IceCube (2017)
 MiRaTA (2017)
 HARP (2018)
 TEMPEST-D (2018)
 RainCube (2018)
 CubeRRT (2018)
 CIRiS (2018*)
 CSIM (2018)

* Target date,
 not yet manifested

International Space Station

Earth Science Operating Missions



External Logistics Carriers: ELC-1, ELC-2, ELC-3
External Stowage Platforms: ESP-3
Alpha Magnetic Spectrometer
Columbus External Payload Facility
Kibo External Payload Facility

■	Formulation
■	Implementation
■	Primary Ops
■	Extended Ops

RECENT and UPCOMING NOTABLE FLIGHT PROGRAM EVENTS

- 2017 Senior Review recommended continuation of most on-orbit missions
 - QuikSCAT full decommission and passivation completed on October 2, 2018
 - TES instrument on Aura discontinued (low availability resulting from hardware issues)
 - RBI discontinued by NASA for technical, cost, schedule issues; work underway to develop an affordable and capable replacement for launch in JPSS-3 timeframe (2026)
 - CATS (ISS) mission ended owing to instrument failure
 - GRACE mission ended after 15 years
 - Jason-2/OSTM moved to lower orbit (IMU redundancy/temperature issues) – continues to provide near-real-time and geodetic measurements
 - CloudSat moved to safe orbit below A-Train (loss of hardware redundancy) – continues to potentially provide high-quality science data
 - Calipso decision to join CloudSat in graveyard orbit for synergistic science
 - TSIS-1 instrument successfully launched to ISS and operating
 - NOAA's JPSS-1 mission successfully launched and operating
 - ICECube, MIRATA CubeSats launched (MIRATA failed once on-orbit); MicroMAS-2 CubeSat successful on JPSS-1 launch
 - TEMPEST-D, RainCube, CubeRRT, successfully launched on OA-9, May 21, 2018 to ISS, deployed 13 July 2018
 - GRACE-FO successfully launched May 22, 2018
 - ECOSTRESS successfully launched 29 June 2018, installed (5 July), operating on ISS
 - ICESat-2 successfully launched September 15, 2018
 - EVI-4 selections: EMIT (hyperspectral aerosol mineralogy/composition) and PREFIRE (Arctic Far-IR emissions from dual CubeSats)
 - OCO-3 completion and delivery to storage Aug, 2018 for launch by February, 2019 (PSR June 13, 2018)
-
- CSIM CubeSats/SmallSats, HARP manifested for launch in 2018
 - GEDI delivery accelerated to allow launch as early as November 27, 2018

ESD Recent Launches

TSIS-1: DEC 15, 2017



TSIS-1

The Total and Spectral Solar Irradiance Sensor (TSIS-1) will measure the total amount of sunlight that falls on Earth, and how that light is distributed among the ultraviolet, visible and infrared wavelengths.

GRACE-FO

Obtain high resolution global models of Earth's gravity field, including how it varies over time

ECOSTRESS

Provide insight into plant-water dynamics & how ecosystems change with climate via high spatiotemporal resolution thermal infrared radiometer measurements of evapotranspiration (ET)

GRACE-FO: May 22, 2018

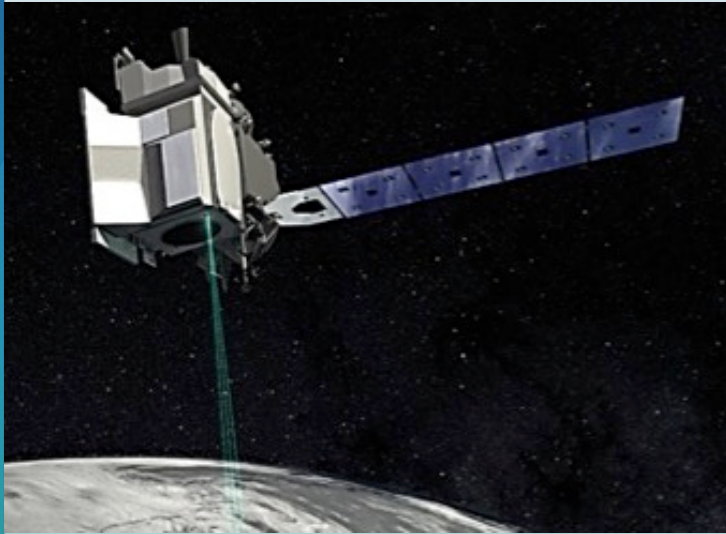


ECOSTRESS: June 29, 2018



ESD Recent and Planned Launches

ICESat-2 – SEP 15, 2018



GEDI



November 2018

OCO-3



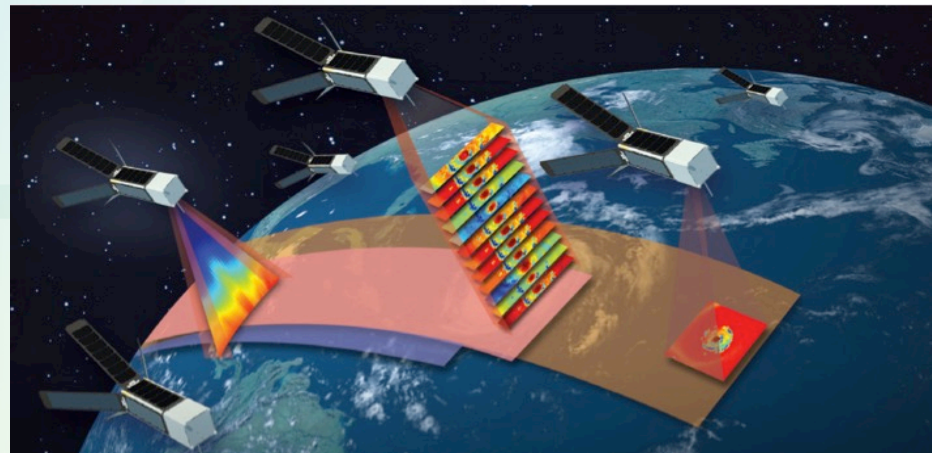
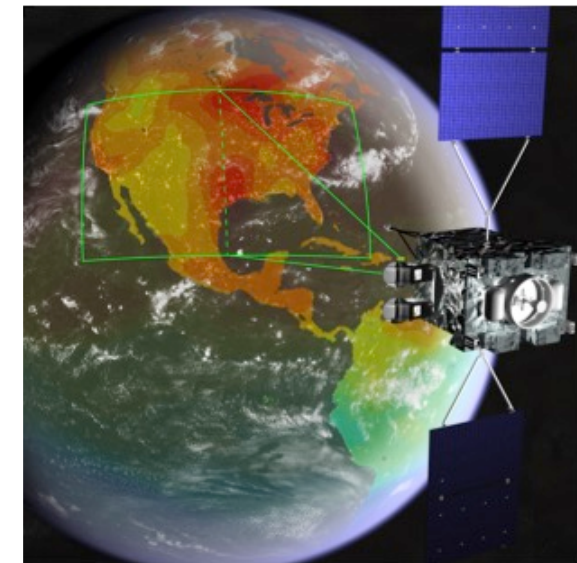
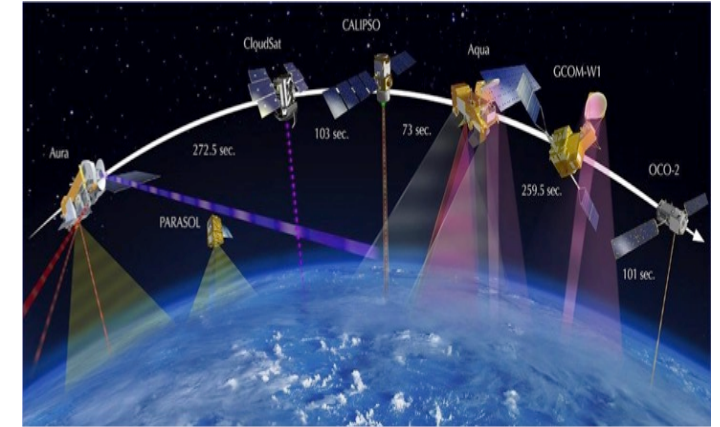
February 2019

ICESat-2 *Quantify polar ice-sheet contributions to sea-level change & measure vegetation canopy height as a basis for estimating large-scale biomass and biomass change*

GEDI *Characterize the effects of changing climate and land use on ecosystem structure and dynamics, providing the first global, high-resolution observations of forest vertical structure*

OCO-3 *Investigate important questions about the distribution of carbon dioxide on Earth as it relates to growing urban populations and changing patterns of fossil fuel combustion.*

NASA Observing System *INNOVATIONS*



Earth Science Division's Venture Opportunities

EVS

Sustained Sub-Orbital
Investigations
(~4 years)

EVM

Complete, self-
contained, small
missions
(~4 years)

EVI

Full function, facility-class
instruments Missions of
Opportunity (MoO)
(~18 months)

Mission	Mission Type	Release Date	Selection Date	Major Milestone
EV-1, aka EVS-1	5 Suborbital Airborne Campaigns	2009	2010	N/A
EVM-1, CYGNSS	SmallSat constellation	2011	2012	Launched Dec 2016
EVI-1, TEMPO	Geosynchronous hosted payload	2011	2012	Delivery NLT 2017
EVI-2, ECOSTRESS & GEDI	Class C & Class D ISS-hosted Instruments	2013	2014	Delivery NLT 2019
EVS-2	6 Suborbital Airborne Campaigns	2013	2014	N/A
EVI-3, MAIA & TROPICS	Class C LEO Instrument & Class D CubeSat Constellation	2015	2016	Delivery NLT 2021
EVM-2, GeoCarb	Geostationary hosted payload	2015	2016	Launch ~2021
EVI-4, EMIT & PREFIRE	Class C ISS-hosted instrument & Class D CubeSat Constellation	2016	2017	Delivery NLT 2021
EVS-3	Suborbital Airborne Campaigns	2017	2018	N/A
EVI-5	Instrument Only	2018	2019	Delivery NLT 2023
EVC-1	Radiation Budget Measurement	2018	2019	Delivery NLT 2024
EVM-3	Full Orbital	2019	2020	Launch ~2025
EVS-4	Suborbital Airborne Campaigns	2021	2022	N/A
EVI-6	Instrument Only	2020	2021	Delivery NLT 2026
EVC-2	Continuity Measurement	2021	2022	Delivery NLT 2027

Open solicitation - In Review
Completed solicitation

Earth Venture Hosted Payloads

- Venture Class enabled an avenue that facilitates hosting instruments on research and non-research spacecraft
- Earth Venture Missions also have the opportunity for hosting arrangements
 - The GeoCarb PI is working with SES to host an instrument at GEO
- We are committed to developing instruments and flying them on non-research satellites when it makes sense
 - TEMPO as the very first Earth Venture instrument selected will be hosted on a commercial geostationary satellite
 - MAIA is the first Earth Venture instrument selected to be hosted on a commercial low earth orbit satellite
- Hosting on commercial spacecraft is predicated on industry stating there is capacity to sell at a mutually advantageous price
- The commercial space community has been supportive in ensuring pathways exists for hosting instruments on commercial satellites
- Alternative access to space may include payload accommodations as a hosted payload (e.g., instrument package) on a U.S.- or non U.S.-provided spacecraft launching on a U.S.- or foreign-manufactured launch vehicle.
- Continued discussions and support for the identifying and removing barriers in the hosted payload community will ensure continued opportunities

Private Sector Small-Satellite Constellation Pilot

- Pursuing contracts with three companies to buy **existing** data products related to ECVs, derived from private sector-funded small-satellite **constellations** (3-satellite minimum constellation, full longitude coverage); **for evaluation by NASA researchers to determine value** for advancing NASA research and applications activities and objectives;
 - Planet – three satellite constellations including 200+ satellites supplying imagery and derived products over the entire Earth
 - DigitalGlobe – operates five satellite constellations that provide very high-resolution (31-50-cm) images
 - Spire – constellation of 48 satellites collecting Radio Occultation soundings and ship reports
- May provide a cost-effective means to augment and complement the suite of Earth Observations
- **Have identified a broad set of ESD-funded researchers who will be supported to assess the value of the geophysical information in the data products for advancing NASA research and applications objectives**
 - 1 year evaluation period
 - Participants primarily chosen from existing ESD-funded community – evaluation support as budget augmentation
 - Written reports to ESD (not scientific papers)
 - Quality of geophysical information
 - Data availability (latency) and subdistribution rights vs. cost
 - Vendor plans for constellation maintenance/evolution
- Blanket Purchase Agreement awards made on September 28, 2018

Earth Science Partnerships

Harnessing commercial and NGO partnerships to amplify our work to understand the Earth as an integrated system and enable societal benefit by essentially leveraging the expertise of NASA and the partners to achieve together what neither could alone.

Current Partners



Activities

- Advancing the ability of remote sensing to inform economic valuation of ecosystem services
 - Increasing the public's access to and use of Earth observations to explore our planet
- Integrating Earth observations into humanitarian decision making to strengthen global resilience to environmental shocks and stressors
- Supporting decision making in smart cities by integrating Earth observations into cloud-based services

R&A Selected Programmatic Highlights

- **Field Work**

- 2018 EXPORTS field program (NE Pacific; in coordination with NSF), HysplRI (Hawaii), ABoVE (Alaska), AVIRIS-ng (Europe); 2019 Cloud and Aerosol Monsoonal Processes Exp't (near Phillipines); FIREX-AQ (Kansas; with NOAA).

- **New Competed Science Programs (highlights only – many ROSES calls)**

- Selected new round of Earth Venture Suborbital Science investigators – 5 missions, \$135M over five years.
- Selected science teams for newly launched missions/instruments (CYGNSS, SAGE III), recompeted existing science teams (Terra/Aqua/S-NPP, Solar Irradiance, OCO-2, Ocean Vector Winds), Solicited for DSCOVR, CCloudSat/CALIPSO, Precipitation Meas. Missions, NISAR Science Teams.

- **Modeling and Data Assimilation**

- GMAO has also implemented a major upgrade of its subseasonal-to-seasonal (S2S) forecast system.
- GISS has recently implemented a new interactive fire module, “PyrE,” into Model E.
- Enabling Capabilities
- Built the second modular computing facility at ARC. New construction started at ARC to expand the computing infrastructure for the future.
- Installed the second antenna to receive GOES-17 data at MSFC.

Earth Science Technology

Advanced Technology Initiatives (ATI)



ACT

Advanced Component Technologies

Development of critical components and subsystems for instruments & platforms

12 projects awarded in 2018. Future solicitations/selections planned in FY 2020 and FY 2023

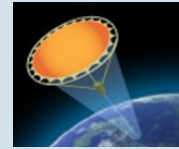


InVEST

In-Space Validation of Earth Science Tech.

On-orbit technology validation and risk reduction for small instruments and instrument systems that could not otherwise be fully tested on the ground or in airborne systems.

Future solicitations/selections planned in FY 2018 & FY 2021



IIP

Instrument Incubator Program

Robust new instrument developments and measurement techniques

17 new projects awarded in FY17. Future solicitations/selections planned in FY 2019 and FY 2022



AIST

Advanced Information Systems Technology

Innovative advances in on-orbit and ground technologies to generate, manage, and exploit data in the 5-20 year horizon

22 new projects awarded in FY17. Future solicitations/selections planned in FY 2018, FY 2020 and FY 2022

Applied Sciences Program: Selected Highlights–2018

Disasters



ROSES call for applications focused on a few disaster types – flood, hurricane, earthquake.

Water Resources

Call to support water resources management. Two-step process planned.

Sustainable Development Goals



Earth science call for applications and research on SDG 14 (oceans) and SDG 15 (life on land).

Food Security and Agriculture Consortium



Effort led by UMD to advance uses of Earth obs for humanitarian pursuits, economic growth, and resilience in food systems in U.S. and globally.

Impact Assessments



VALUABLES Consortium conducting economic studies on Earth science; also arranging venues for Earth scientists wanting to learn about policy and economic terms/methods.

SERVIR



New Amazonia regional hub for South America is planned to open in Spring.

DEVELOP



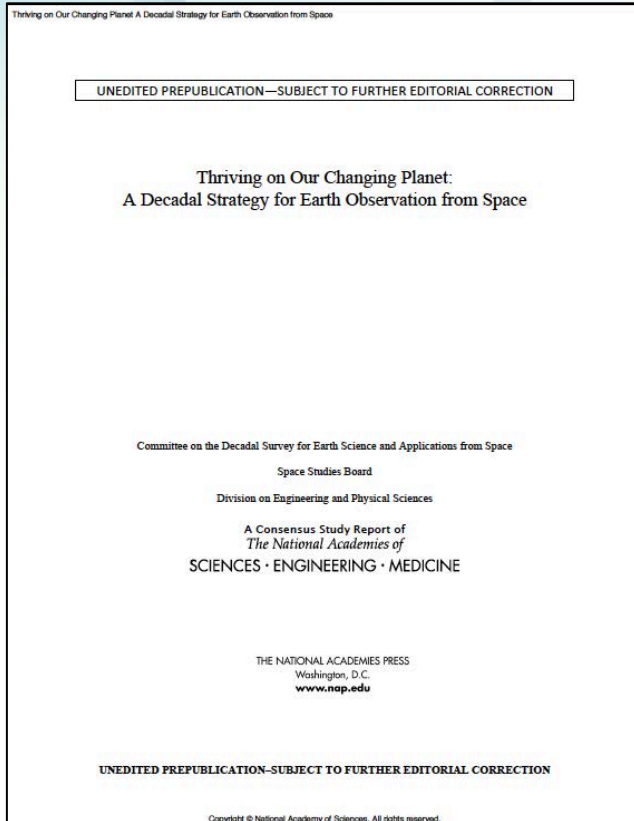
2018 marks the 20th year for this development, workforce & Earth science applications program.

ARSET Trainings

Over 15 professional-level hands-on and webinar trainings on remote sensing to reach people across all 50 U.S. States again in 2018.

2017 Decadal Survey Snapshot

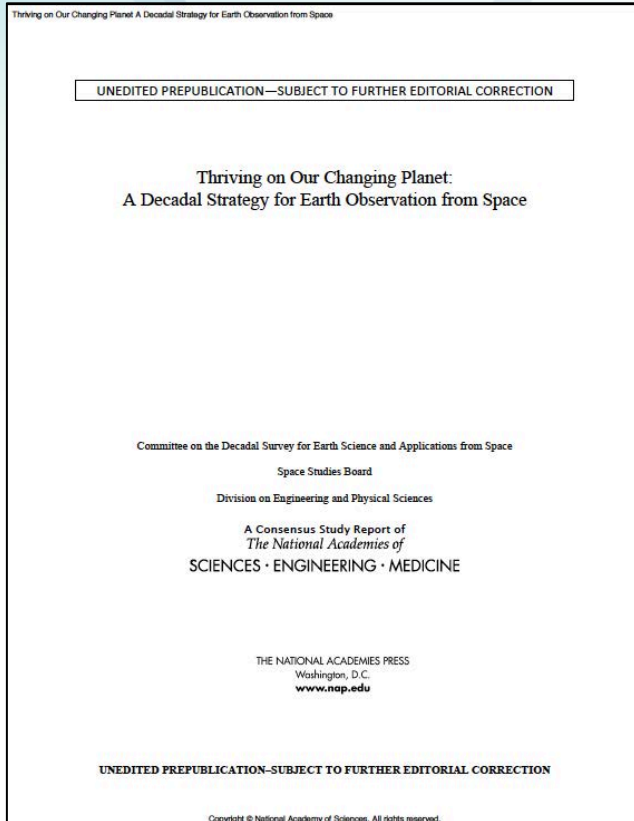
2017 DECADAL SURVEY



- Publicly released January 5, 2018
- Supports the ESD (and international) *Program of Record*
- Prioritizes *observations* rather than specific missions
- Emphasis on *competition* as cost-control method
- Explicitly allows *implementation flexibility*
- Explicitly encourages *international partnerships*
- Endorses *existing balances* in ESD portfolio

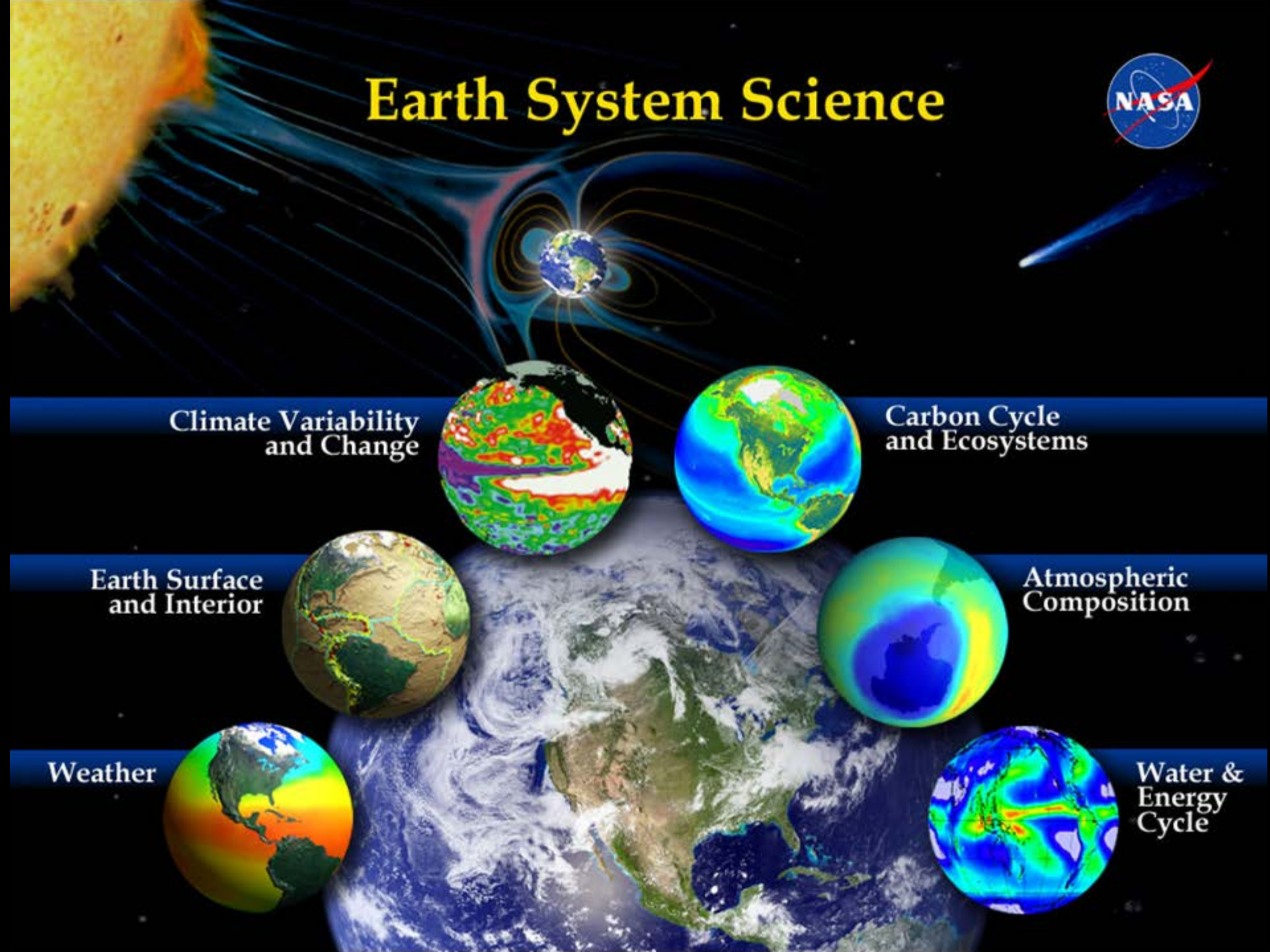
2017 Decadal Survey Snapshot (cont.)

2017 DECADAL SURVEY



- Recommends “Continuity Measurement” strand (\$150M full mission cost “cap”) as an addition to the existing Venture-class program
- Identifies 5 “Designated” observables for mandatory acquisition (*Aerosols; Clouds, Convection, & Precipitation; Mass Change; Surface Biology & Geology; Surface Deformation & Change*)
- Calls for “cost-capping” essentially all mission
- Introduces a new competed “Explorer” flight line with \$350M cost constraint, 3 observables to be chosen by ESD from among 6 identified
- Calls for “Incubator Program” between Technology, R&A, and Flight to mature specific technologies for important – but presently immature – measurements (preparation for next Decadal)
- ***ESD is conducting focused community forums (for ~18 months) to translate the recommendations into an executable program and, for Flight, a portfolio of specific, realistic, launch-ordered missions and solicitations.***
 - Decadal new mission budget wedge opens only in late FY21

Earth System Science



Climate Variability
and Change

Carbon Cycle
and Ecosystems

Earth Surface
and Interior

Atmospheric
Composition

Weather

Water &
Energy
Cycle